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Fault Analysis in Transmission Line and Time Inverse over Current Relay evaluation Using Matlab Simulink

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Abstract
A power system is exposed to faults, because of natural disasters or by disoperation of the system due to operators' negligence. As a result, permanent damage to power system components leading to considerable costs for their replacement and in longer disconnections of power supply to customers, which is highly undesirable.

INTRODUCTION
Now a days, In modern engineering world, aTransmission lineis a specialized cable or other structure designed to carryalternating currentat set frequency to different areas of utilizations, that is, currents with a frequency high enough that their wave nature must be taken into account. But then also these transmission lines are not get sent percent result in their main work(i.e. transmitting electricity) and other hand job works such as Transmission lines are used for purposes such as connecting radio transmitters and receivers with their antenn as, distributing cable television signals,trunk lines routing calls between telephone switching centers, computer network connections and high speed computerdata buses. Similarly for distributing electricity in various areas such as industries,cooperate offices, homes we required help of various electricity equipments such as transformers, circuit breakers, isolators etc and these equipments also failed in their employment due to occurrence of various faults.

This set a requirement for a power system to sustain faults, whilst protection structures must decrease the damage in critical additives and the impact of faults as plenty as possible. This is carried out via using power machine protection strategies and methodologies. Microprocessor-based totally relays have their personal algorithms for tracking the energy device thru present day and voltage inputs from CTs and VTs respectively.

These Protection relays goes to numerous relay test sets to confirm their dependence and safe operation before commissioning them in a substation ,large power systems can be simulated and their behavior can be analyzed in both steady state and faulted conditions. Based on this analysis, protection system and power system controllers can be developed for more efficient, reliable and safe operation of power systems.

OVERCURRENT RELAY
On this relay the actuating quantity is most effective cutting-edge i.e. within the production of this protective relay best cutting-edge operated element is required no voltage coil and many others are required.

As the name states, an overcurrent relay presents protection towards over currents. There would be essentially a modern-day coil. This relay makes use of current inputs from a CT and compares the measured values with preset values. Whilst regular present day flows via this coil, the magnetic impact generated via the coil isn't always sufficient to move the moving element of the relay, as in this condition the restraining force is more than deflecting pressure. If the enter modern price exceeds the prevailing cost, the magnetic impact will increase, and after certain level of modern-day, the deflecting pressure generated by means of the magnetic impact of the coil, crosses the restraining force, as a end result, the shifting detail starts offevolved moving to exchange the contact role inside the relay i.e. the relay detects an overcurrent and troubles a ride signal to the breaker which opens its contact to disconnect the included device. Whilst the relay detects a fault, the circumstance is called fault pickup. The relay can ship a experience signal straight away after choosing up the fault (in the case of immediately overcurrent relays) or it may watch for a particular time earlier than issuing a trip sign (within the case of time overcurrent relays). This time delay is also known as the operation time of the relay.

Classifications of Over-Current Relays

Overcurrent relays are classified on the basis of theiroperation time, in the following three categories:

1) Instantaneous Overcurrent Relay:

These relays instantaneously send a trip command to the breaker as soon as the fault is detected, in this a magnetic core is wound by current coil and A piece of iron is so fitted by hinge support with restraining spring in the relay, that when there is not sufficient current in the coil, the NO contacts remain open while as soon as when current in the coil crosses a present value, the attractive force becomes sufficient to pull the iron piece towards the magnetic core and consequently the No contacts are closed. They do not have any intentional time delaybut there is always an inherent time delay which can not be avoided practically. They are usuallyimplemented close to the source wherethe fault current levelis very high and a small delay in operation of relay can cause heavy damage to the equipment. So an instantaneous relay is used there to detect and respond to a fault in few cycles.

2) Definite Time Overcurrent Relay:

This type of overcurrent relay is used for backup protection (e.g. back up protection for transmission linewhere primary protection is distance relay). It is created by applying intentional time delay after crossing pick up value of the current. If the distance relay does not detect a line fault and does not trip the breaker, then after a specific time delay, the overcurrent relay will send a trip command to the breaker. In this case, the overcurrent relay is time delayed by a specific time which is just greater than the normal operating time of the distance relay plus the breaker operation time.**It** can be adjusted to issue a trip output at definite amount of time after it picks up.Hence, it has a time setting adjustment and pick up adjustment.

3) Inverse Definite Minimum Time (IDMT) OvercurrentRelay:

Natural character of any induction type rotating device is an Inverse time characteristics. This means that the relay operating time is inversely proportional to the fault current .i.e. the speed of rotation of rotating art of the device is quicker if input present day is accelerated. For the electromechanical induction disc relay these herbal function could be very suitable for over modern safety. That is because, on this relay, If the fault cutting-edge is better, the working time might be lesser. An IDMT overcurrent relay traits depends at the form of general decided on for the relay operation. These standards may be ANSI, IEEE, lAC or consumer defined. The calculation of the operation time of relay is completed via the use of the feature curves and their corresponding parameters. By means of the implementation of any of the above noted standards the function curve for an overcurrent relay may be recognize very without problems. The overcurrent relay will then calculate the operation time corresponding to that precise function curve.

TIME INVERSE PROTECTION

On the basis of primary schemeto protect power systems, the time inverse relay works. In this relays the fault signal (indicating the fault occurrence) is tripped in a time indicated by a delay-time versus overcurrent (TOC) curves. The purpose of TOC curves is to allow the protection schemes to respond faster orslower depending on the magnitude of the faulted current thus avoiding the disconnection long section of the electrical network .i.e. the relay operating time that is time delay in the relay is inversely proportional to the magnitude of actuating quantity. The TOC curves are also useful to coordinate the operation of the numerous protection relays installed in an electrical network.

Inverse time delay is achieved in induction disc relay by providing a permanent magnet in such a way, that, when disc rotates, it cuts the flux of permanent magnet. due to this, present day is prompted inside the disc which slows down the movement of the disc. A solenoid relay can be made inverse time relay, through providing a piston and a oil dash-pot. A piston, connected to the shifting iron plunger, is immersed in oil in a sprint-pot. When the solenoid relay is actuated, the piston moves upwards together with iron plunger. Viscosity of oil slows the upward motion of plunger. the speed of this upward movement in opposition to gravity also relies upon how strongly the solenoid attracts the iron plunger. This appeal force of the solenoid depends upon the significance of actuating present day. Consequently, time of operation of relay is inversely proportional to actuating cutting-edge.

Two parameters are needed to setup an overcurrent relay: 1) the pick-up (tripping) current, and 2) timedelay. The pick-up current is defined as the minimum current level that initiate the relay protective function. The time delay is a current-level dependent variable used to create a set of different curves suited for coordination of several time-inverse relays.

The ANSI/IEEE C37.112 “Standard Inverse-Time Characteristic Equations for Over-current Relays” defines the following four main curve sets:

Moderately Inverse Curve: Primary used as backup protection for transformers banks.

Inverse Curve: It is used where there is a widevariation in the magnitude if the fault current.

*Very Inverse Curve:*It is used were variations for the fault current is rather small and where fast trip in closer faults is an important issue.

Extremely Inverse Curve: This curve characteristic is the one that resembles the most with the operation curve of fuses. Thus is the one who better coordinates with fuses and restores in the same circuit.The characteristics of overcurrent relays are represented with the following equation:

$$\boldsymbol{T} = \left[\frac{\boldsymbol{C}}{\left(\frac{\boldsymbol{I}}{\boldsymbol{Is}}\right)^{\boldsymbol{\alpha}} - \boldsymbol{1}}\right] \times \mathbf{TMS}$$

T: Relay operation time.
C: Constant for relay characteristic.
Is: Current Set point.
I: Current Input to the relay.
α: Constant Representing Inverse Time Type (α >0).
TMS: Time Multiplier setting controls the relay tripping time.

DIFFERENT TYPES OF INVERSE HARACTERISTICS CURVES

Relay characteristics type	**α**	**C**
Standard inverse	0.02	0.14
Very inverse	1	13.5
Extremely inverse	2	80
Long inverse	1	120

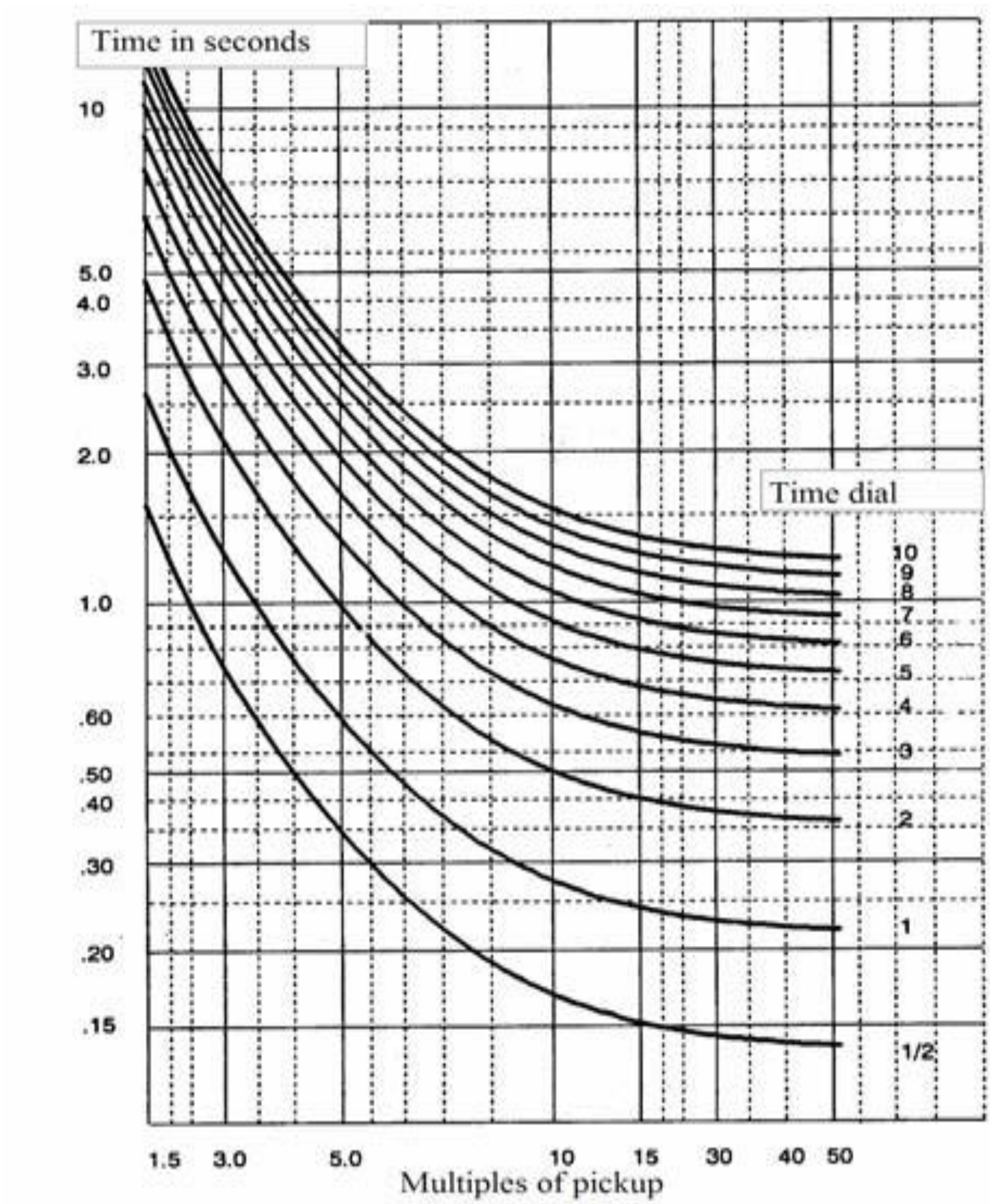


Fig. 1.*Transmission Line Model.*

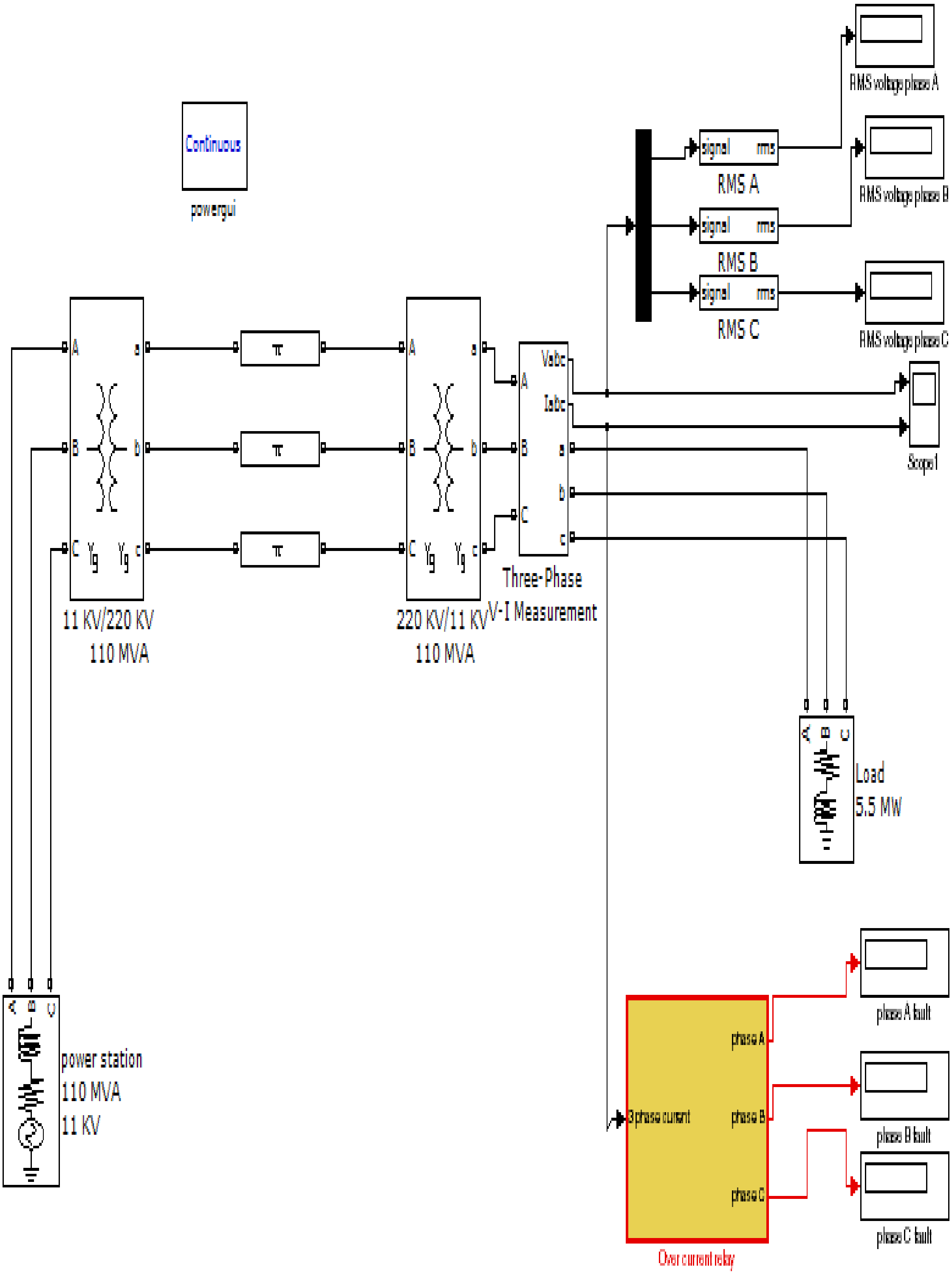


Fig. 2.*Overcurrent Relay Model.*

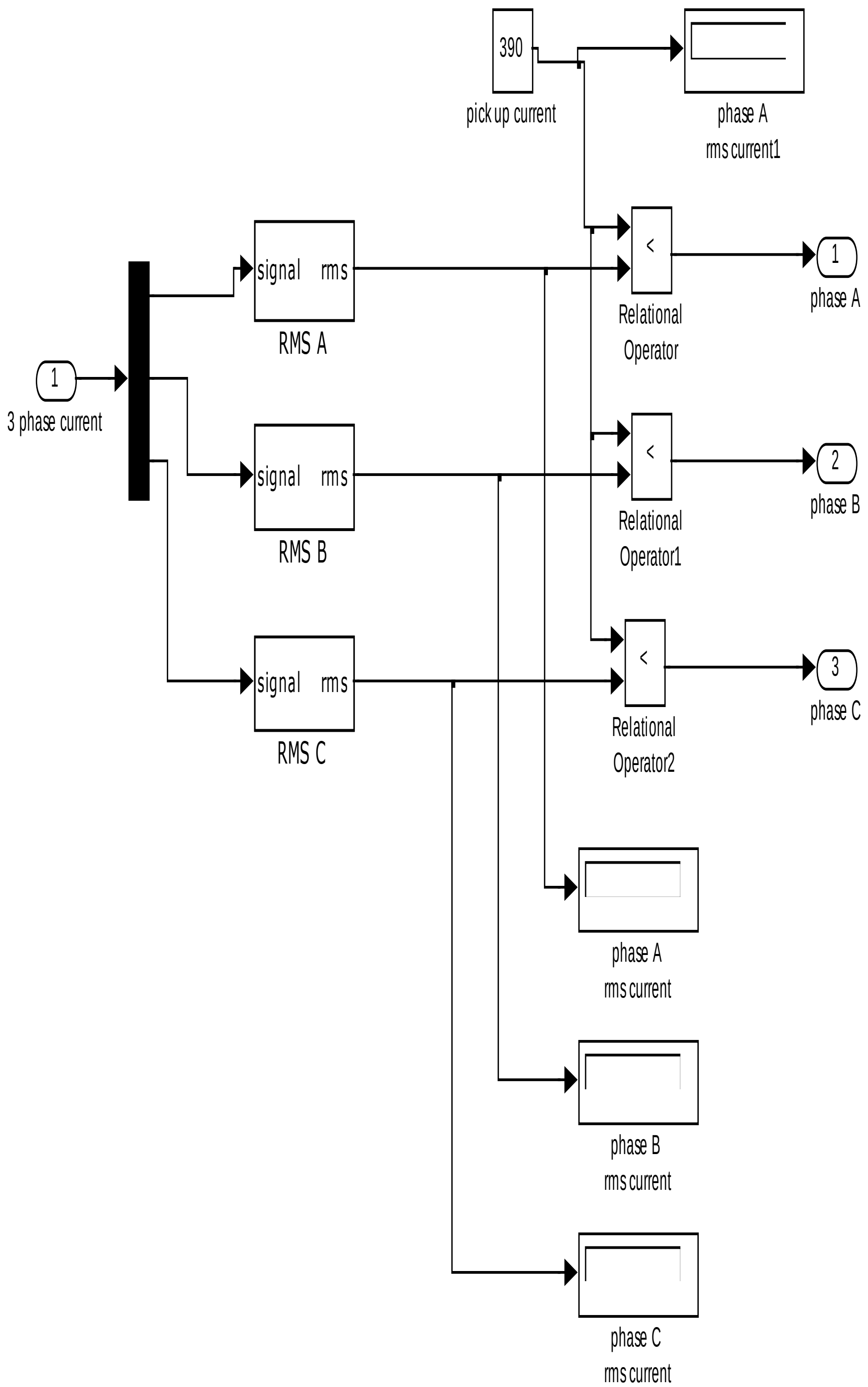
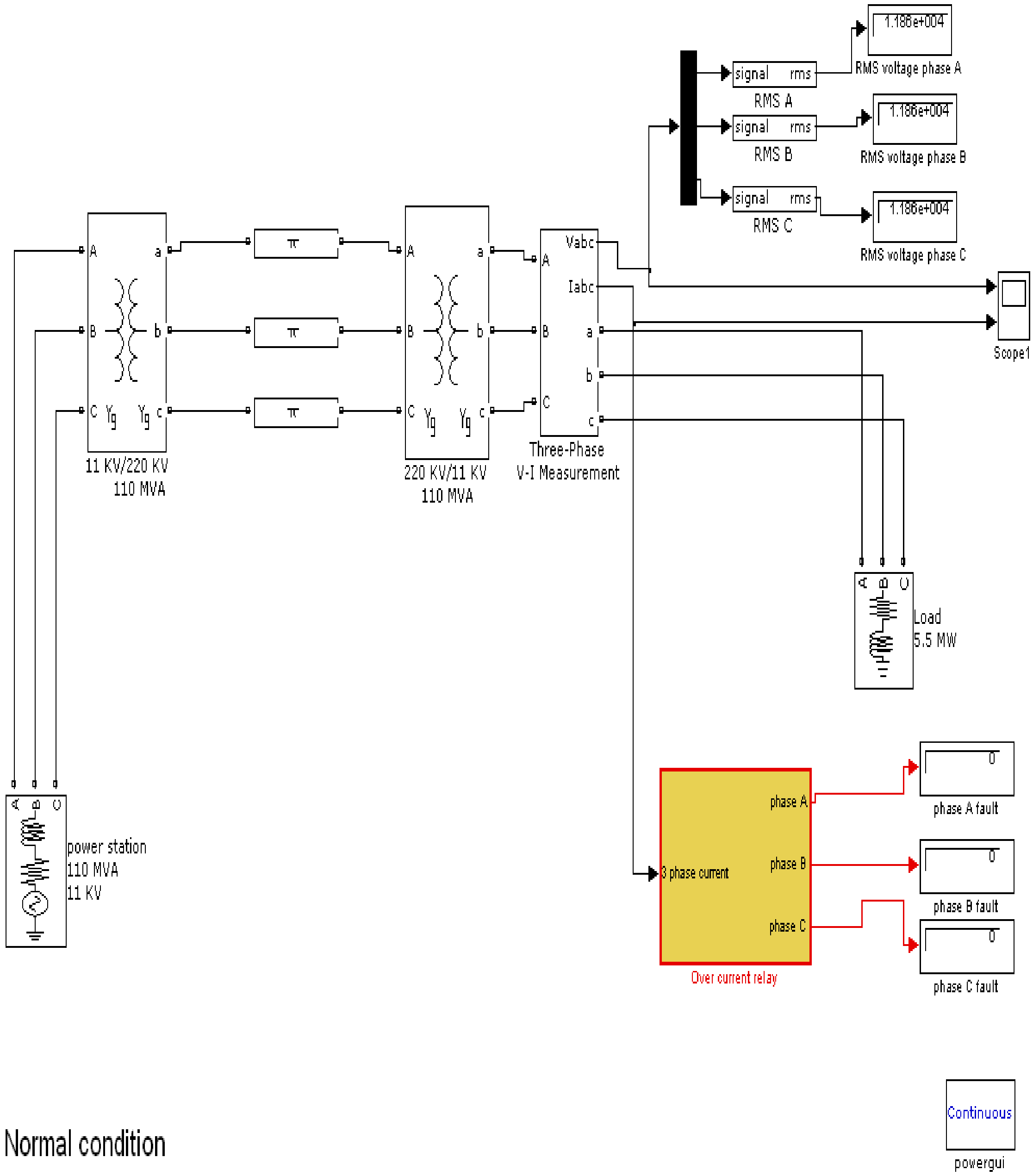


Fig. 3. *Overcurrent Relay Internal Model.*

NORMAL CONDITION



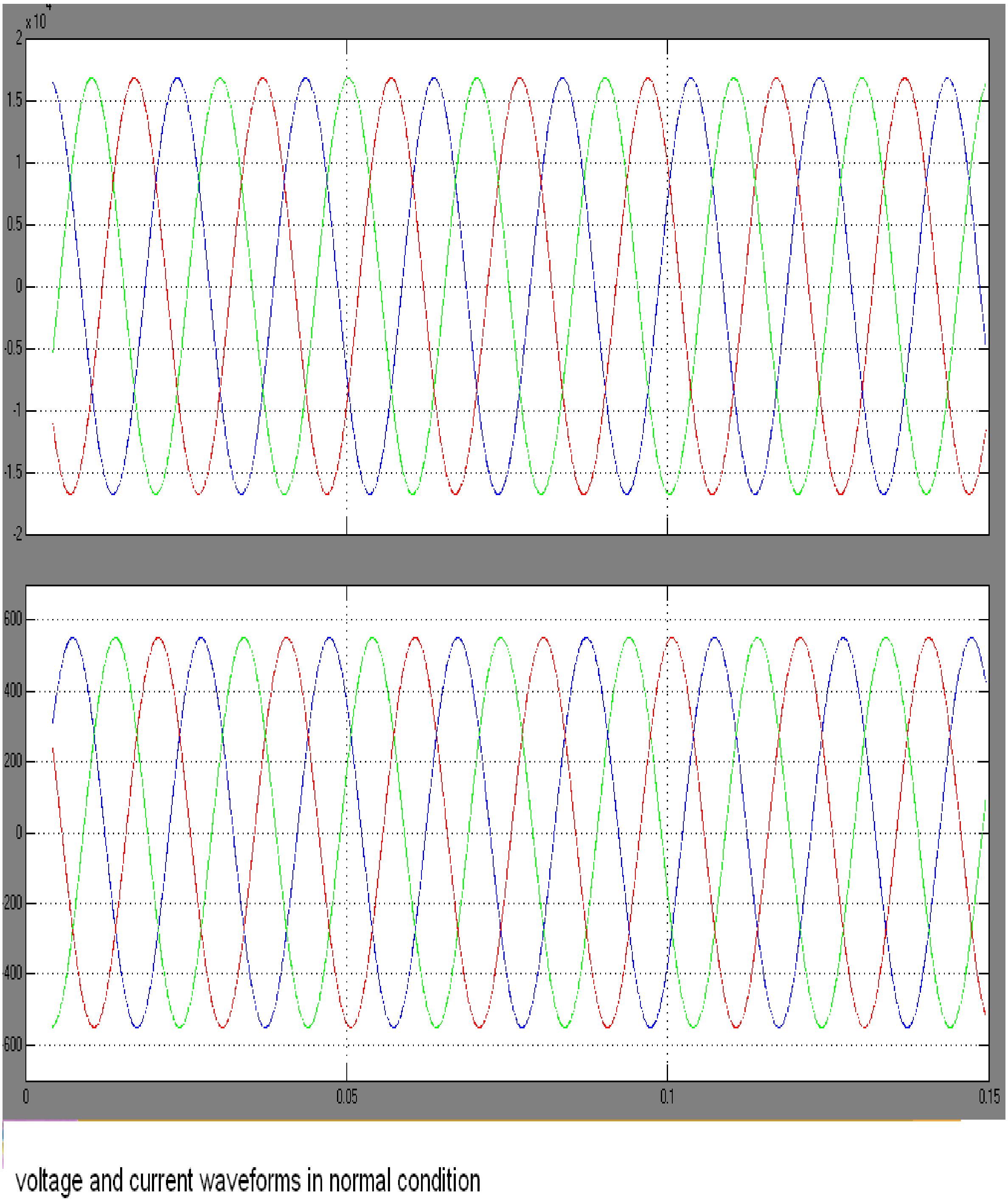


Fig. 4.*Output Voltage and current waveform in normal conditions.*

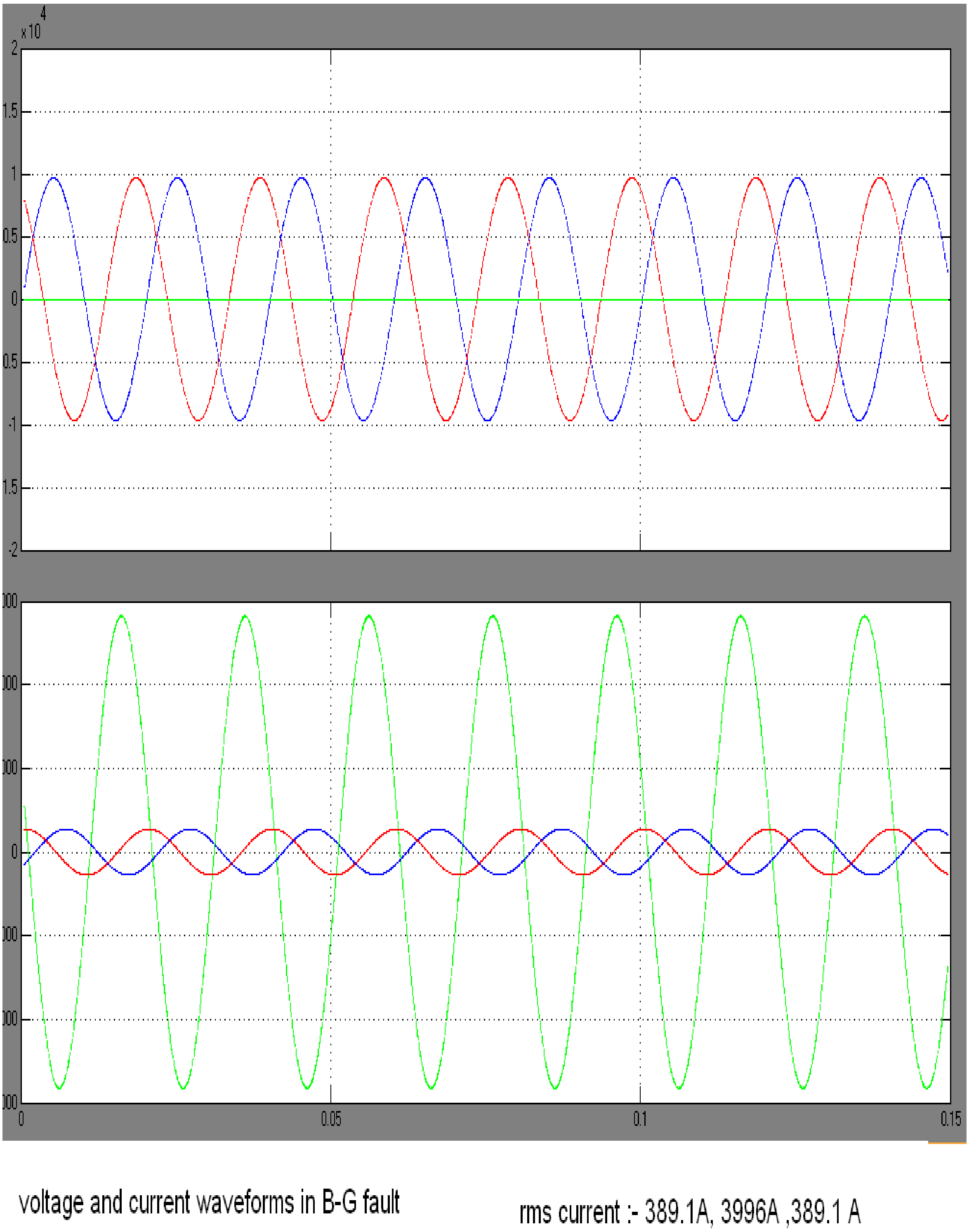


Fig. 5.*Output Waveform of Voltage and Current wavefoem in L-G fault.*

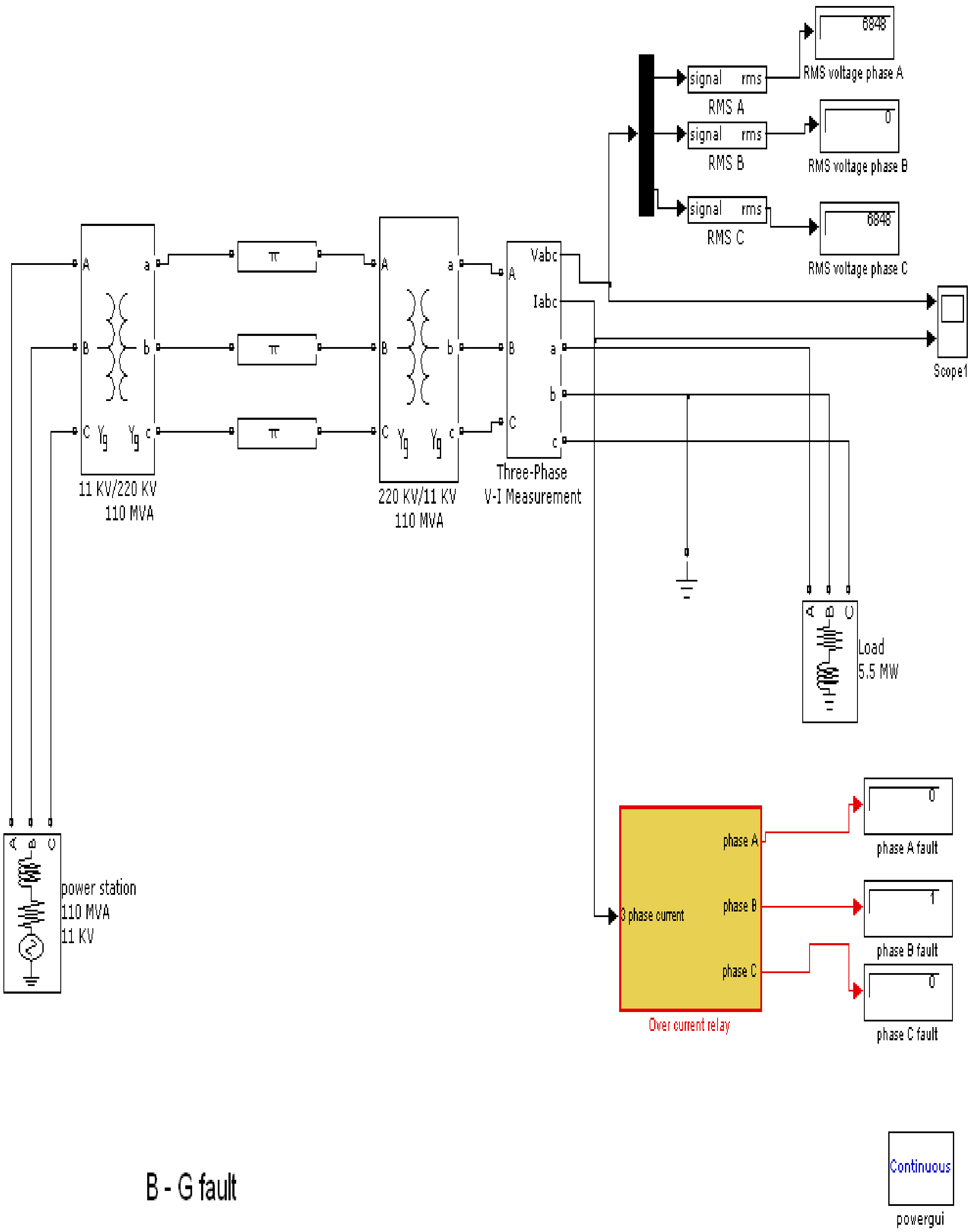
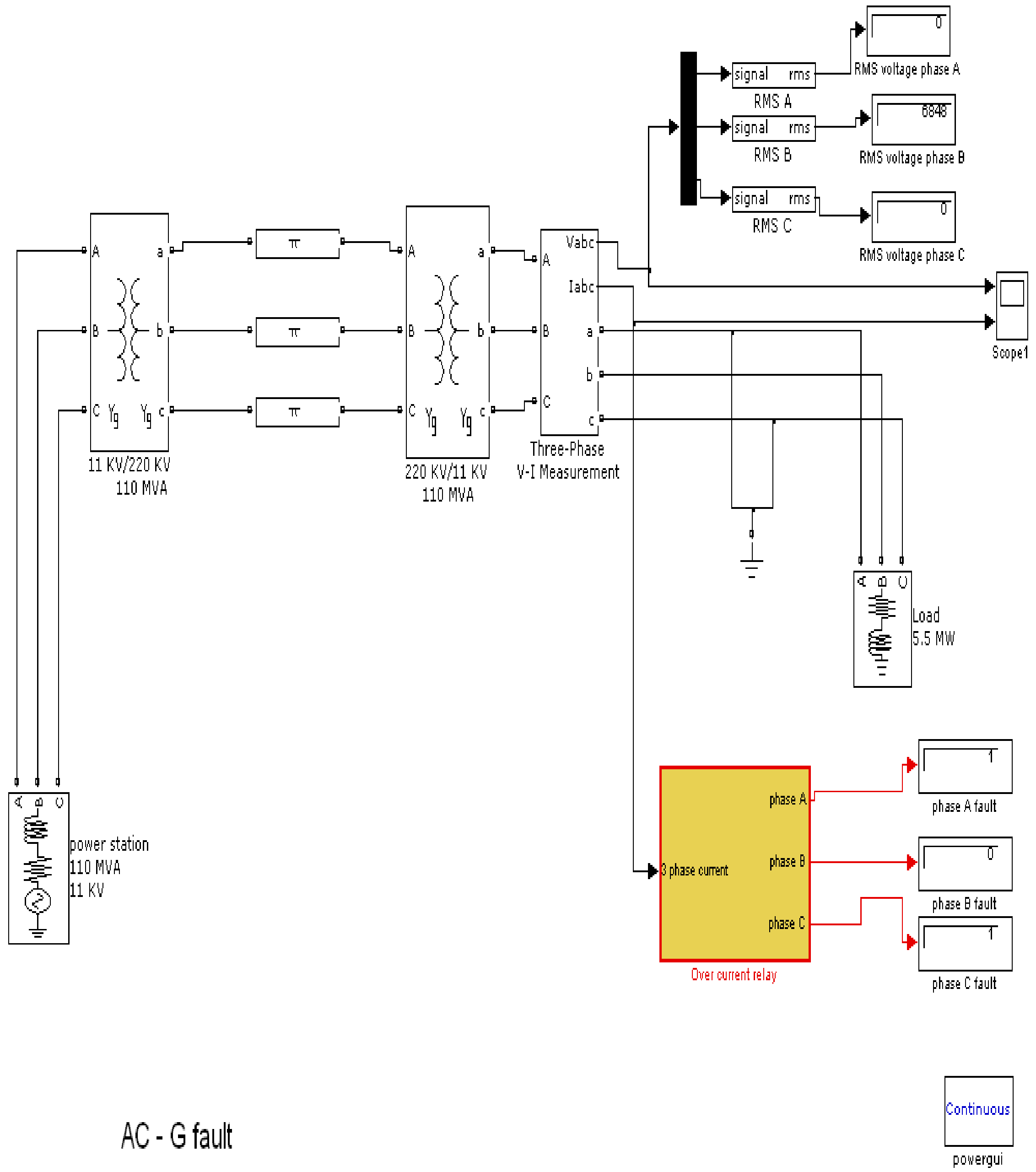
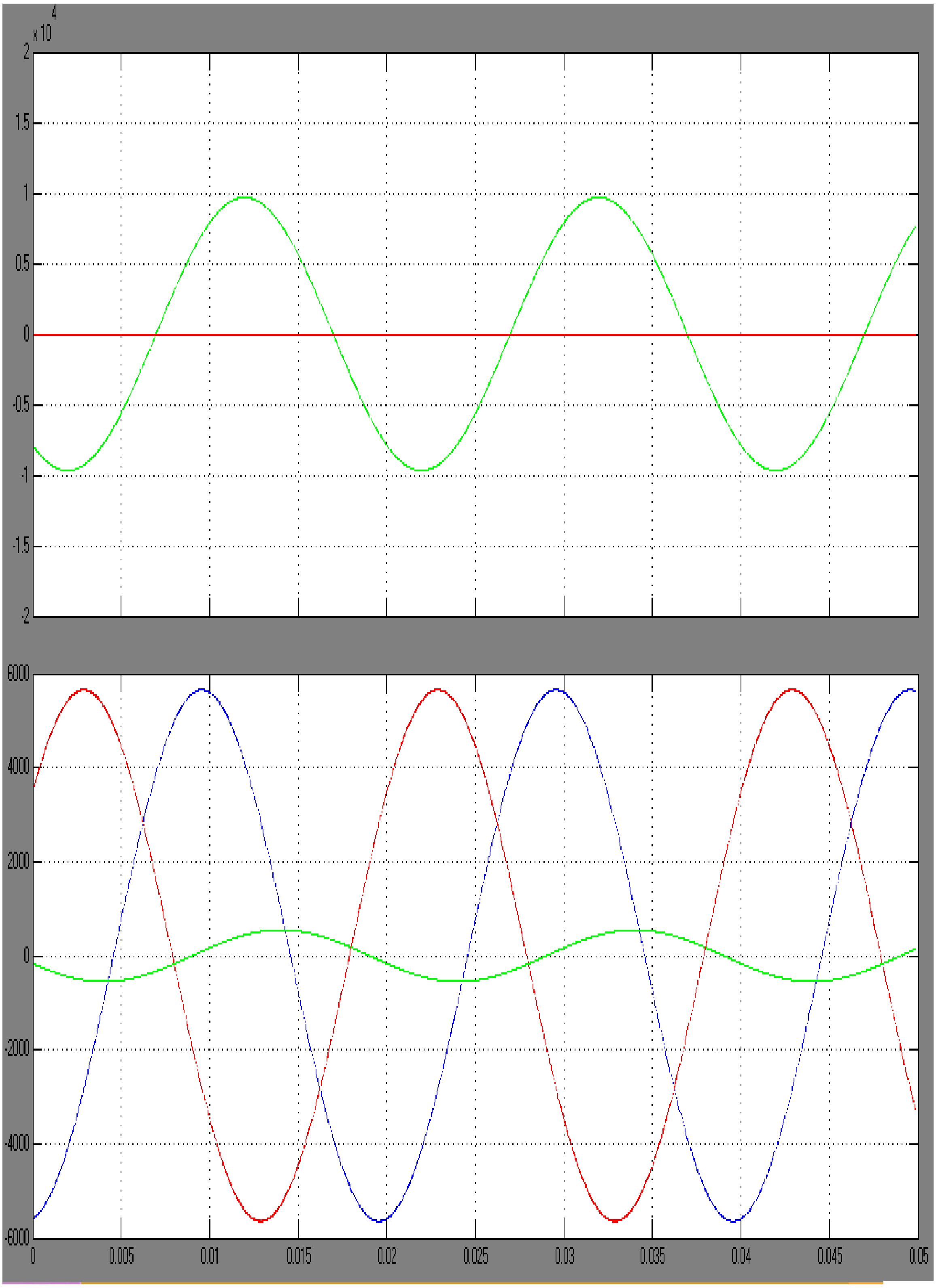


Fig. 6.Diagram of L-G Fault.

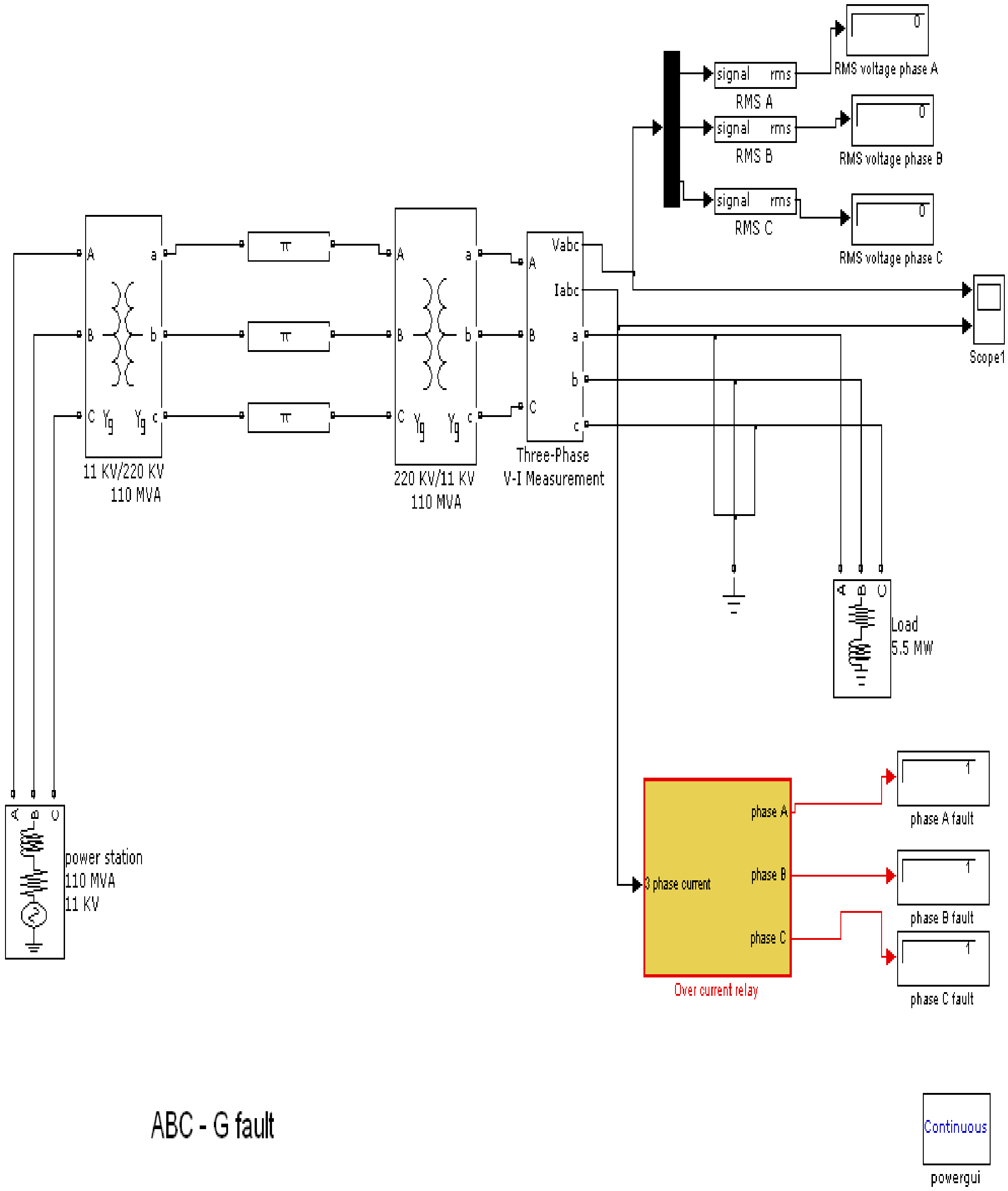
L-L-G FAULT

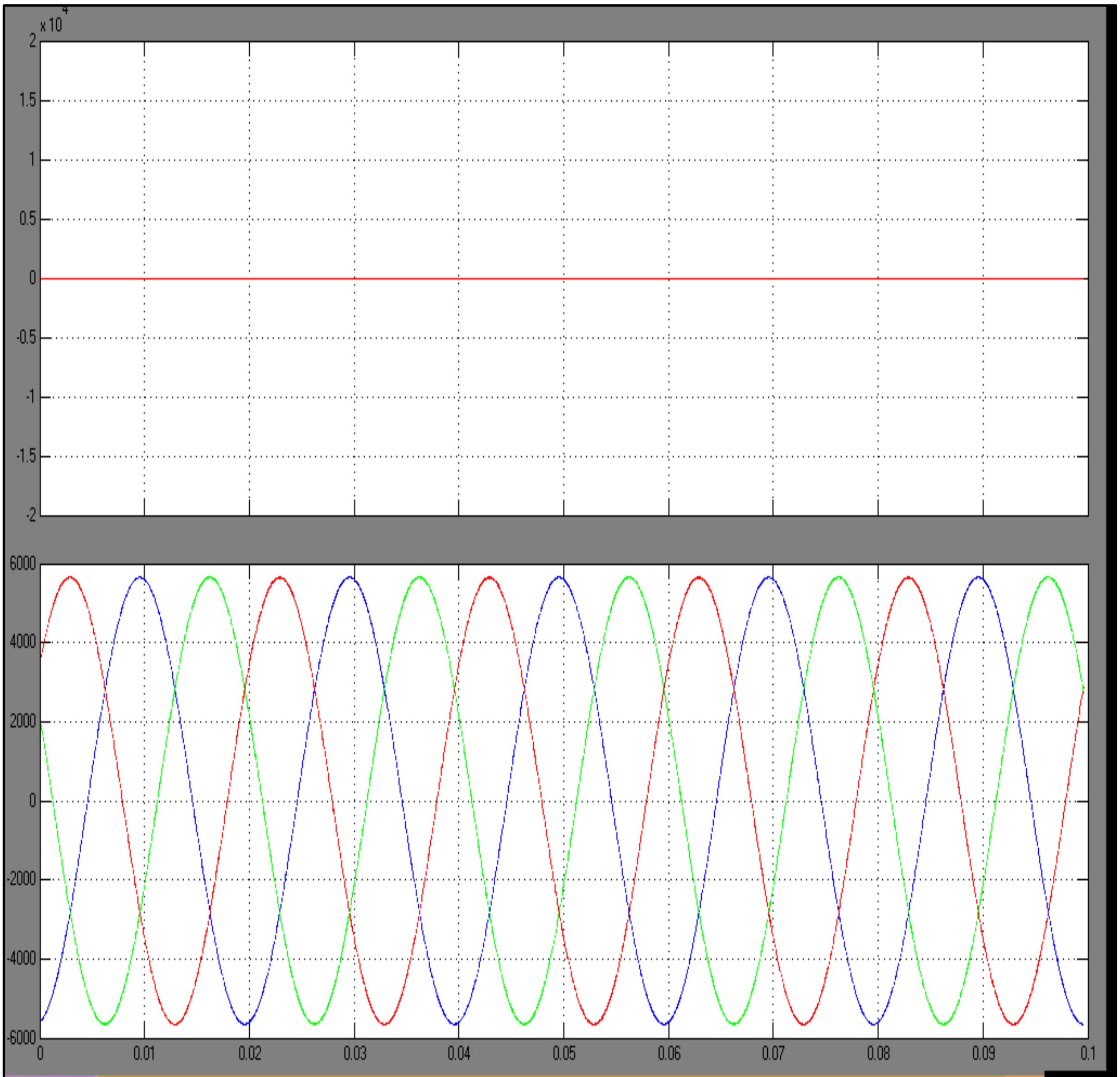

signal rms
RMS A
signal rms
RMS B
signal rms
RMS C
RMS voltage phase A
RMS voltage phase B
RMS voltage phase C
6848
Scope1
Vabc
Iabc
11 KV/220 KV
110 MVA
220 KV/11 KV
110 MVA
Three-Phase
V-I Measurement
Load
5.5 MW
power station
110 MVA
11 KV
3 phase current
phase A
phase B
phase C
Over current relay
phase A fault
phase B fault
phase C fault
AC - G fault
Continuous
powergui



voltage and current waveforms in AC - G fault   Rms currents :- 3996 A, 389.1 A, 3996 A

PHASE FAULT


signal rms
RMS A
RMS voltage phase A
signal rms
RMS B
RMS voltage phase B
signal rms
RMS C
RMS voltage phase C
11 KV/220 KV
110 MVA
220 KV/11 KV
110 MVA
Vabc
Iabc
Three-Phase
V-I Measurement
Scope1
Load
5.5 MW
power station
110 MVA
11 KV
3 phase current
phase A
phase B
phase C
Over current relay
phase A fault
phase B fault
phase C fault
ABC - G fault
Continuous
powergui



voltage and current waveforms in ABC -G fault Rms current :- 3996 A (in all phase)

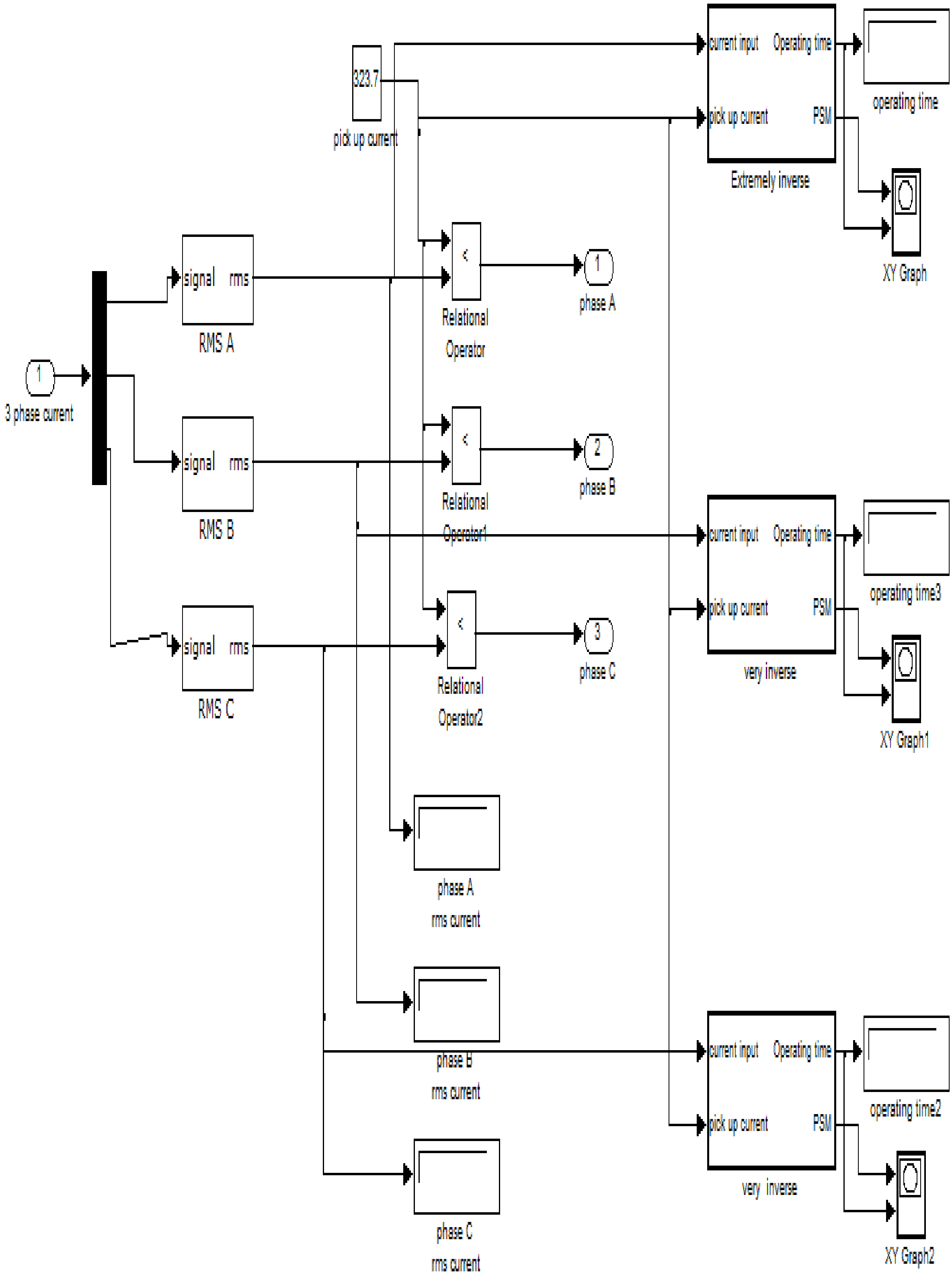


Fig. 7.*Overcurrent relay model with time inverse characteristics.*

Extremely inverse curve model for calculating operating time

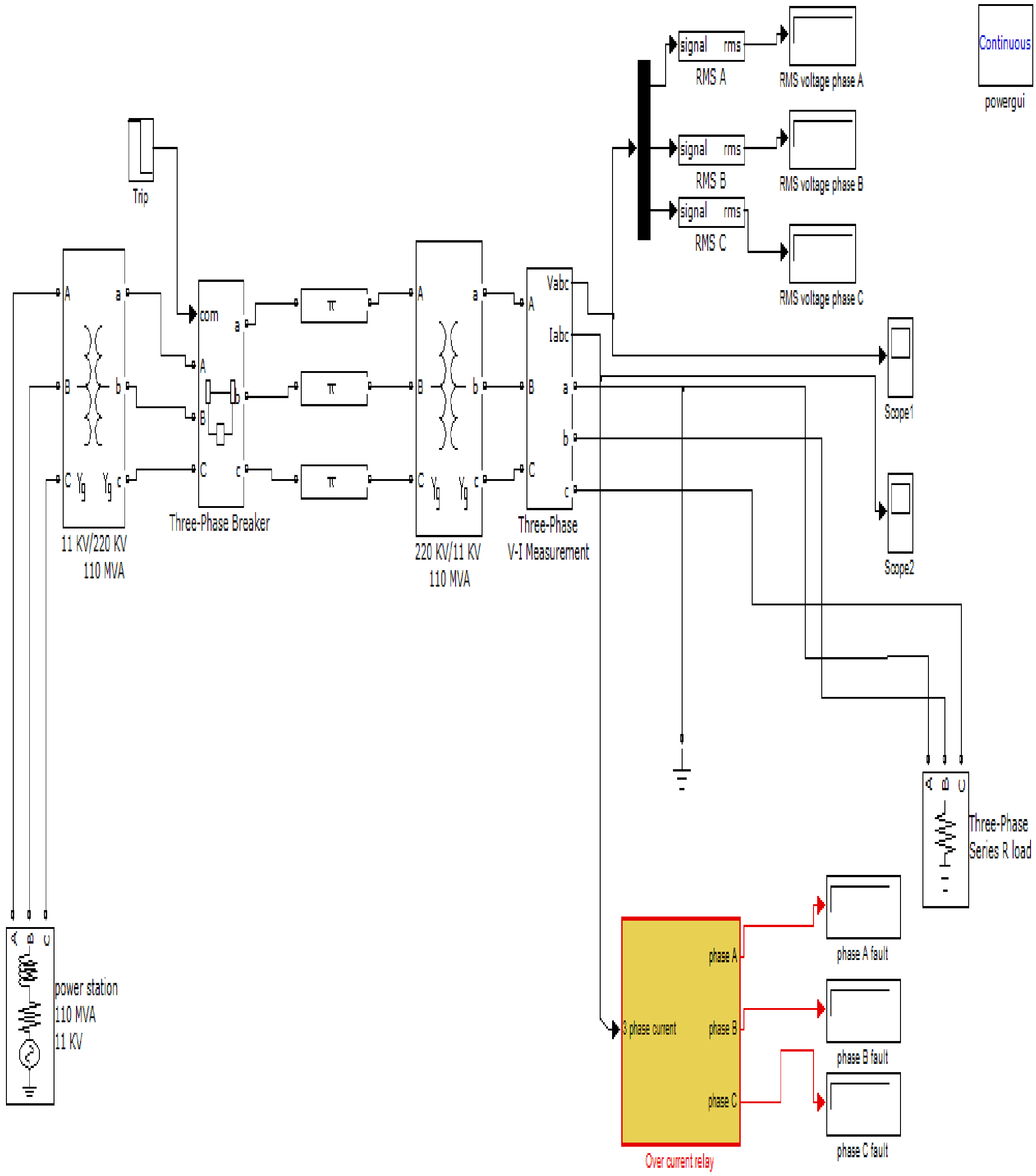
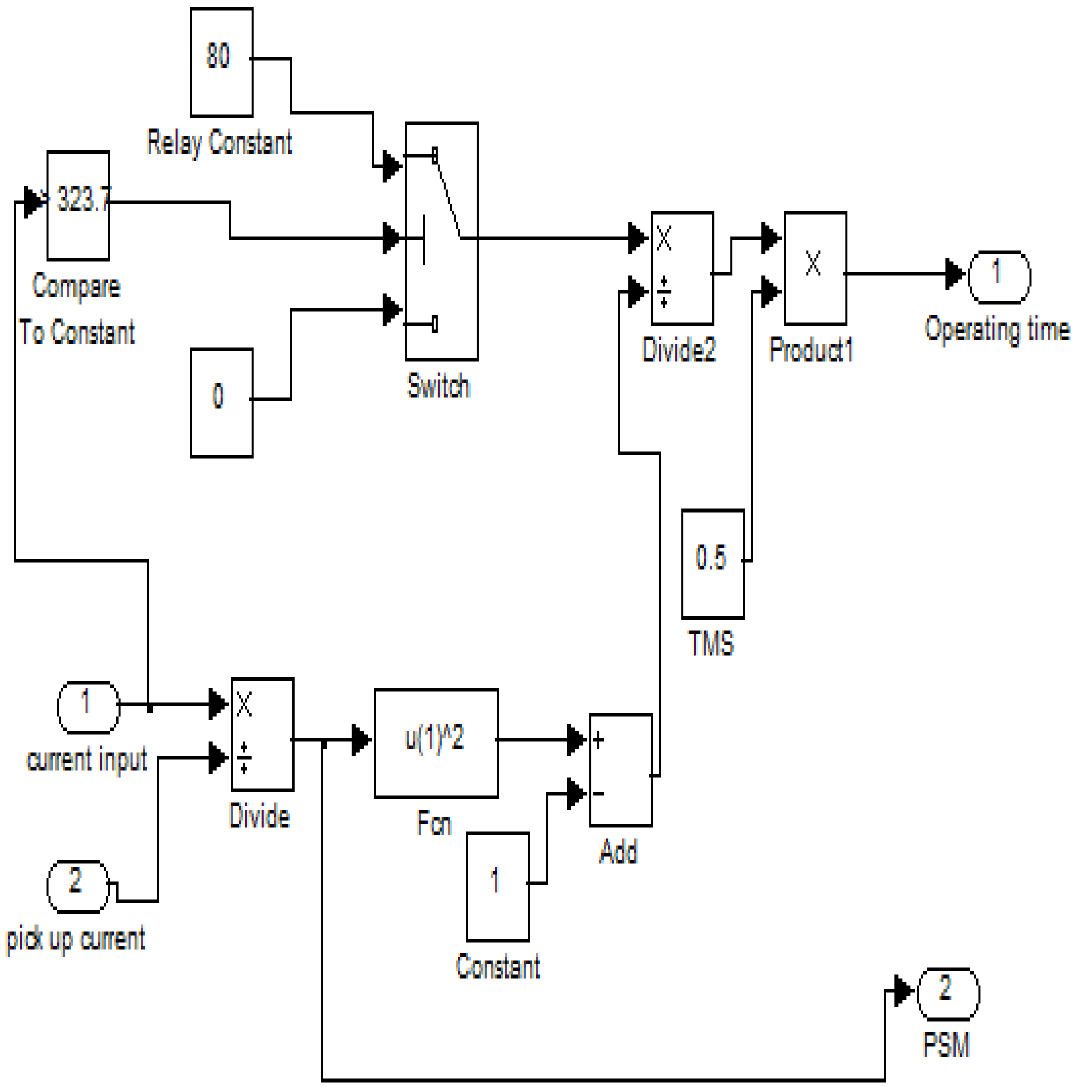


Fig. 8.*G fault ,operating time of Extremely inverse overcurrent Relay=0.1745 sec.*


80
Relay Constant
323.7
Compare
To Constant
0
Switch
X
÷
Divide2
X
Product1
1
Operating time
0.5
TMS
1
current input
X
÷
Divide
2
pick up current
u(1)^2
Fcn
+
-
Add
1
Constant
2
PSM

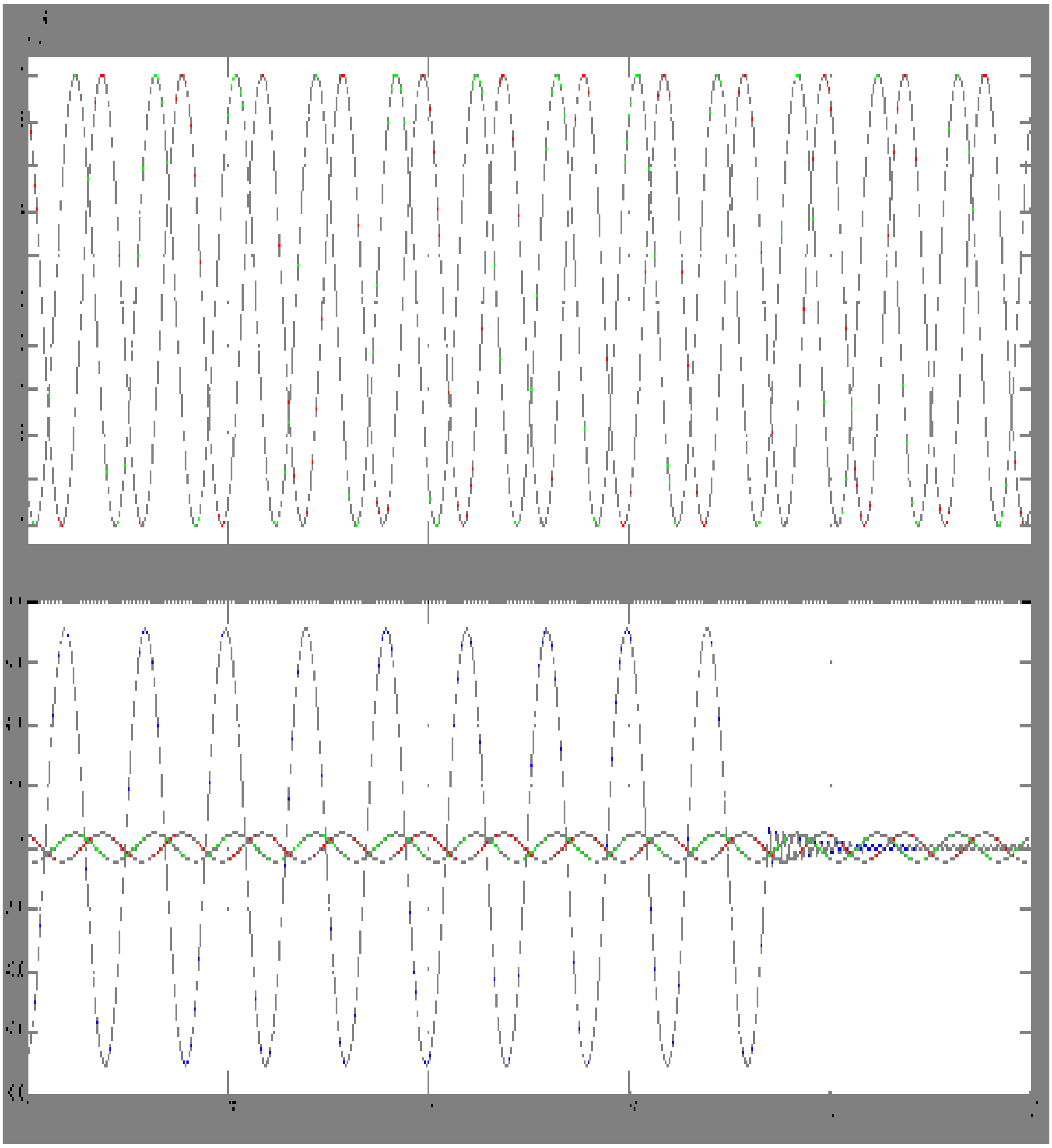


Fig. 9.*Fault current in phase A =5007 A (rms) phase A trip at t=0.1745 sec*
Phase A extremely inverse curve for TMS=0.5, x -axis= PSM, and y-axis= operating time.

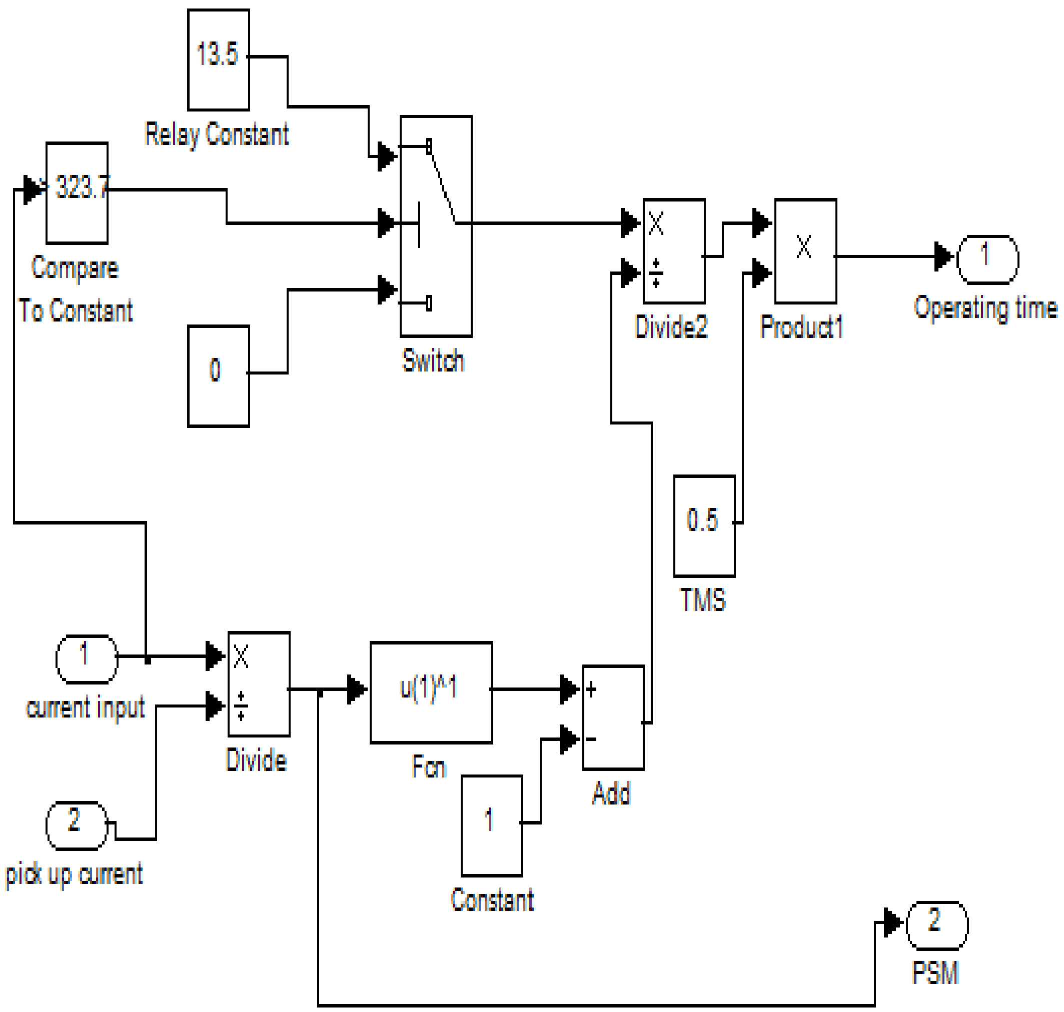


Fig. 10.*Very inverse curve model for calculating operating time.*

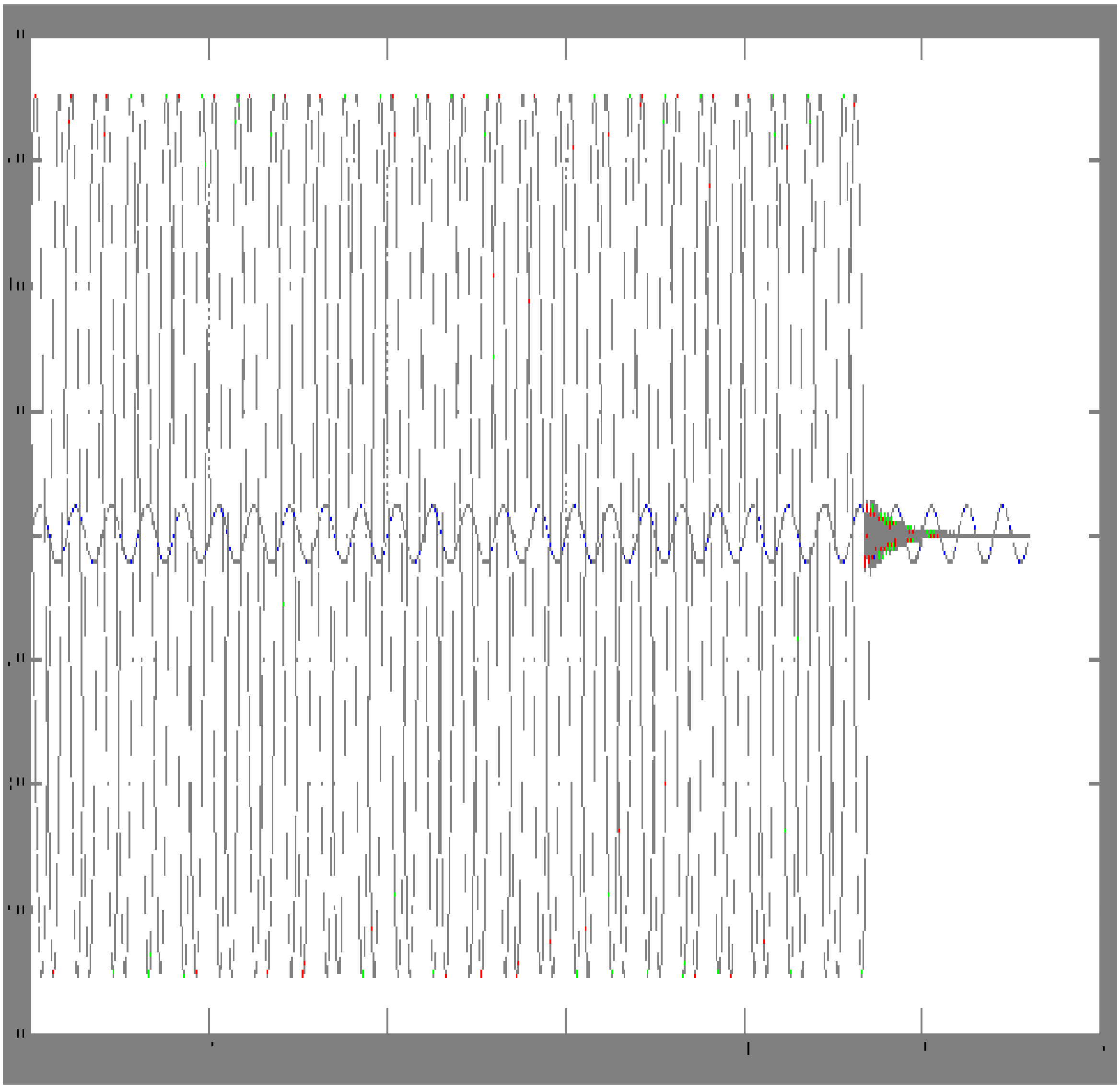


__Fig. 11.__Fault current in phase A and B=5007 A (rms) phase B,C trip at t=0.4666 sec.

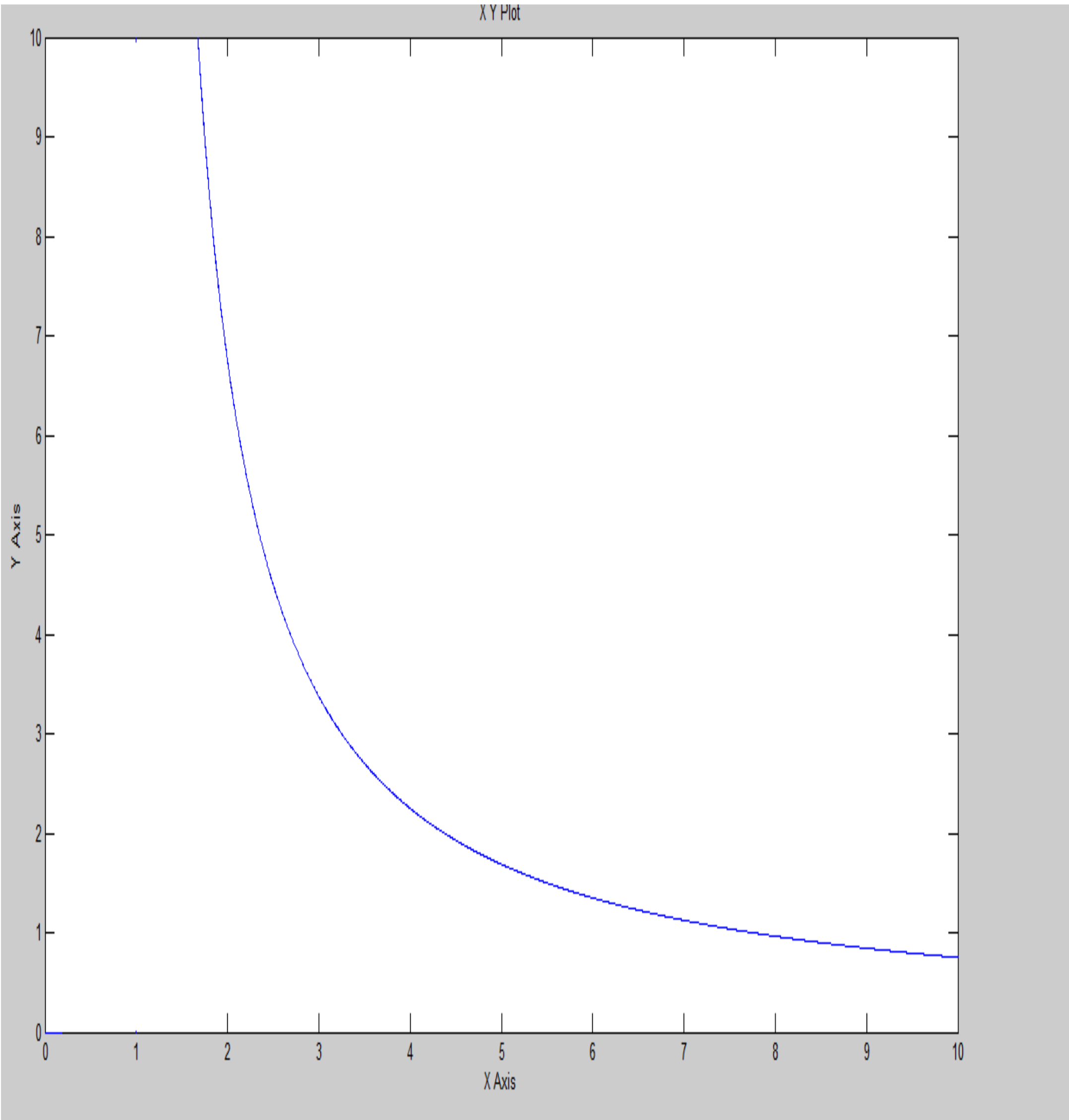


Fig. 12.*Phase B and C very inverse curve for TMS=0.5.*

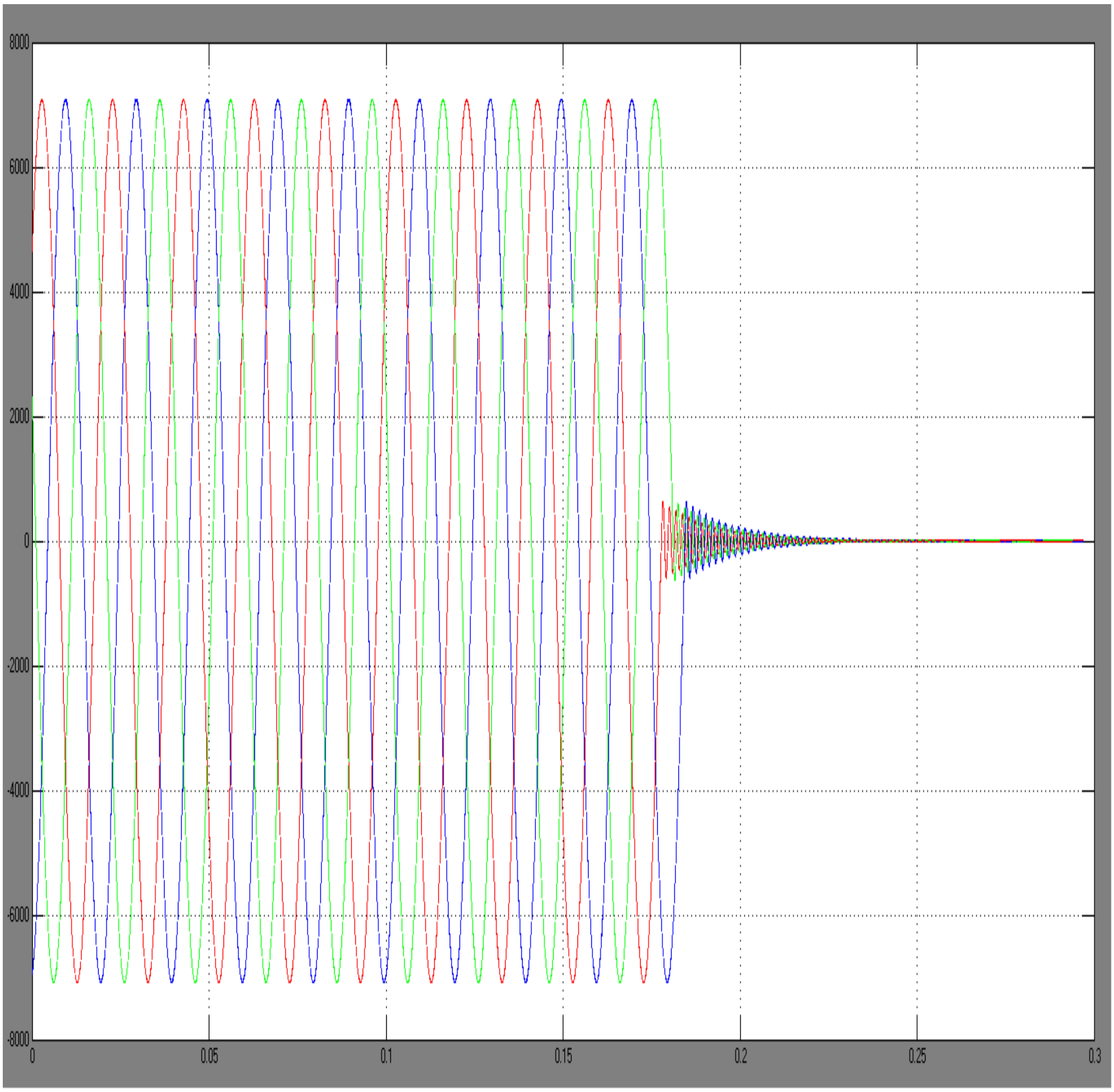


Fig. 13.Fault current in phase A,B and C = 5007 A (rms) phase A,B,C trip at t=0.1745 sec.

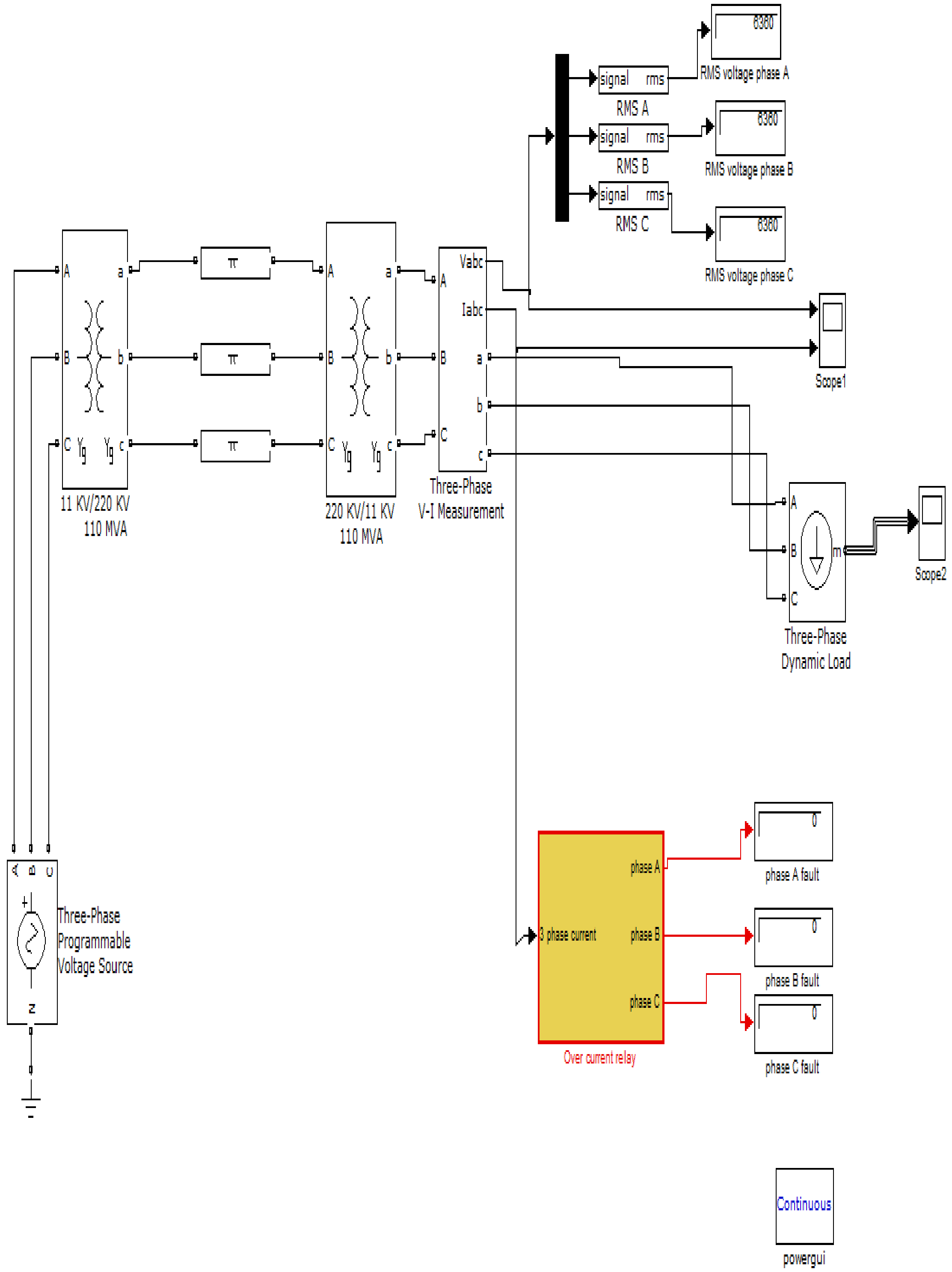


Fig. 14.*Power system model with three phase programmable voltage.*

SOURCE AND THREE PHASE DYNAMIC LOAD

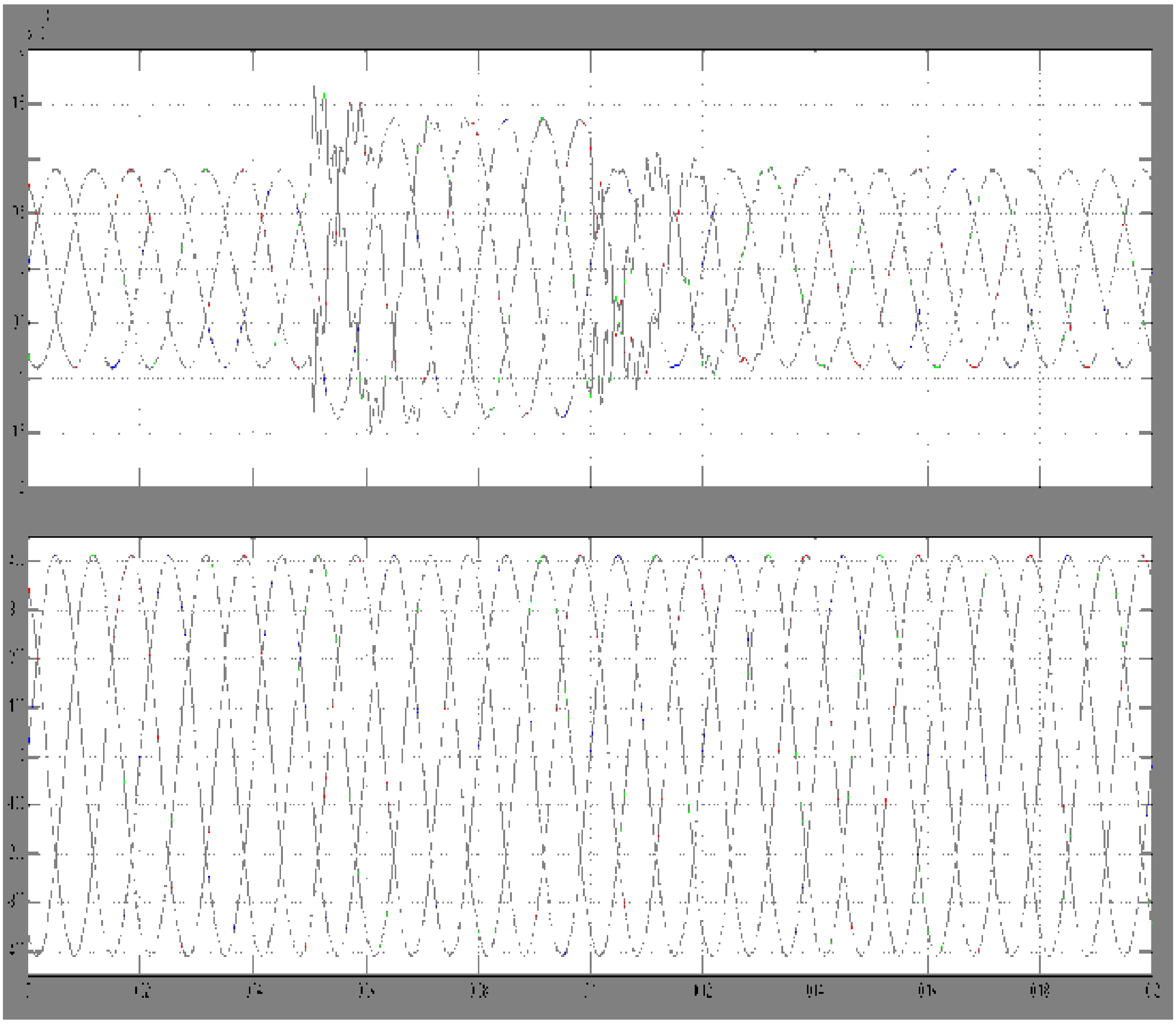


Fig. 15.*Variation of voltage between time t=0.05 to 0.1 sec.*

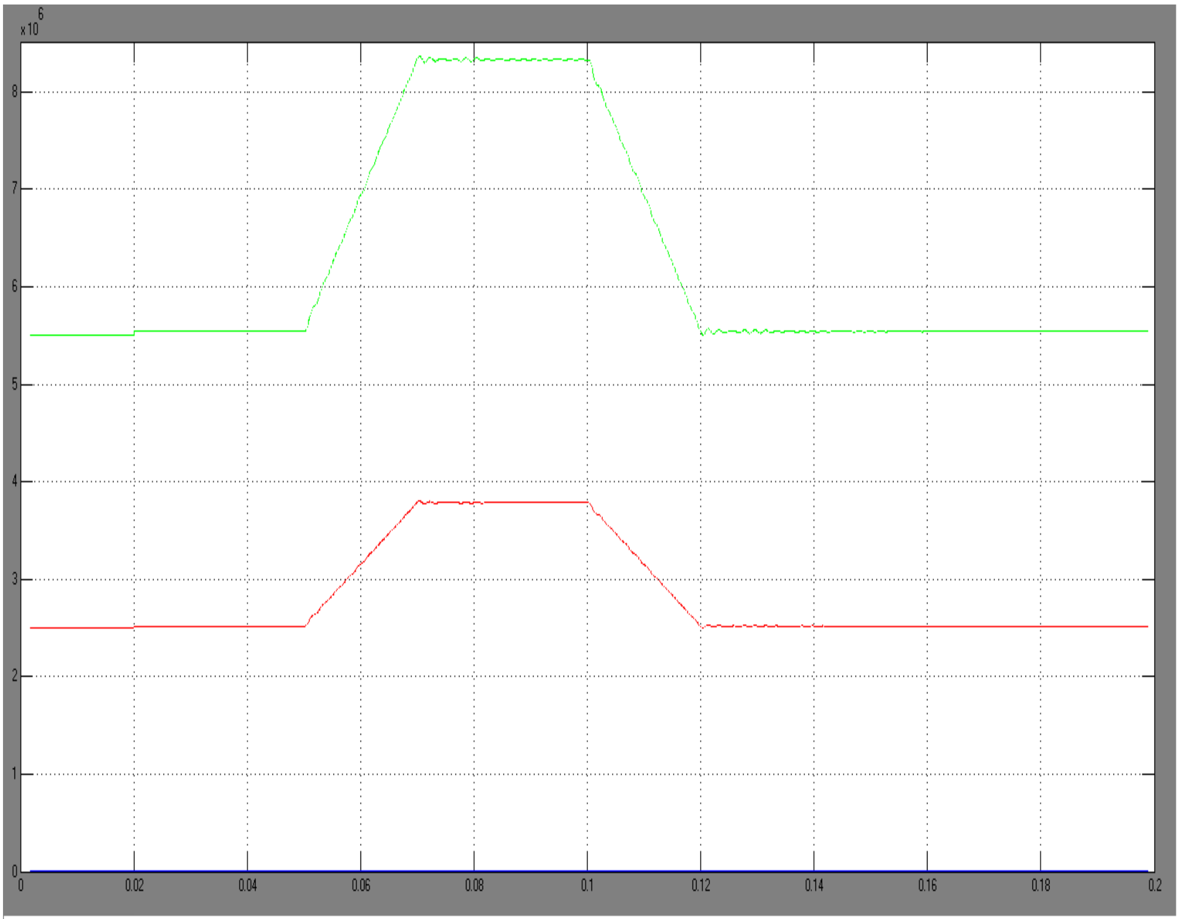


Fig. 16.*Variation of active and reactive power with variation of amplitude of source voltage between time 0.05 to 0.1 sec.*

CONCLUSION

Circuit breaker and over current relay is interconnection relation among every different. Testing of circuit breaker and over current relay is accomplished by using MATLAB/SIMULINK and contrast between calculated running & experience sign time.

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